Remarks

Thorough examination by the Examiner is noted and appreciated.

Claim 1 has been amended to more narrowly define the invention continued therein.

No new matter has been added.

Claim Rejections under 35 USC 103(a)

1. Claims 1-29 and 42-52 stand rejected under 35 USC Section 103(a) as being unpatentable over Lin et al. (US 6,342,448) in view of Chung et al. (USPUB 2003/0057526).

Lin et al. disclose a method for forming an improved TaN barrier layer. Lin et al. disclose forming a first Ta layer followed by a middle TaN layer followed by an upper Ta layer (see Abstract). Lin et al. teach that the upper Ta layer (18 to 22 Angstroms thick) improves wetting of an overlying copper seed layer (see e.g., col 9, lines 8-25). Lin et al. disclose CVD or sputtering of a single copper seed layer over the Ta barrier

layer (see col 5, lines 52-64).

Thus, Lin et al. do not disclose several aspects of Applicants disclosed and claimed invention.

Nowhere do Lin et al. disclose or suggest **plasma treating a copper seed layer following deposition of a copper seed layer.**

Nowhere do Lin et al. disclose forming **a first and second seed layer on a diffusion barrier layer.**

Lin et al. disclose and teach formation of a **single copper seed layer by CVD or sputtering (PVD) on the composite barrier layer** (with the copper seed layer being 1200 to 2500 Angstroms thick) (col 9, lines 13-20).

Nowhere do Lin et al. disclose or suggest:

"forming a diffusion barrier layer to line the damascene opening;

then forming a first seed layer on the diffusion barrier;

then plasma treating the first seed layer in-situ with a first treatment plasma **formed from plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;**

then forming a second seed layer on the first seed layer;"

On the other hand, Chung et al. disclose a method of forming a barrier layer with a **first copper alloy seed layer** and a **second undoped copper seed layer** to improve adhesion of a copper seed layer to an underlying barrier layer and to prevent dewetting of the copper seed layer by agglomeration in subsequent thermal processes (see Abstract; col 1, paragraph 008; paragraph 0059; paragraph 0061; paragraphs 0068-0070; claims 1, 8, an 17)

Contrary to Examiners assertion, nowhere do Chung et al. disclose or suggest **plasma treating** the first seed layer **following formation** of the first seed layer and **prior to formation** of the second seed layer as Applicants have disclosed and claimed. Rather, Chung et al. disclose **plasma annealing** a **TaN barrier layer prior to depositing a seed layer** (see paragraph 0047). Chung discloses that **"any suitable technique to deposit**

the seed layer may be used" including PVD, CVD, electroless deposition or a combination of techniques. Suitable PVD techniques include (HDP-PVD) (see paragraph 0050, 0053, 0065).

Examiner mistakenly equates Applicants disclosed and claimed **plasma treatment following the first seed layer formation** to be taught by Chung who discloses that **"any suitable technique to deposit the seed layer may be used" including PVD, CVD, electroless deposition** or a combination of techniques. Suitable PVD techniques include (HDP-PVD) (see paragraph 0050, 0053, 0065). Examiner therefore **argues the first seed layer deposition (including using argon to form the plasma)** of Chung et al. is **"plasma treated" prior** to the formation of the second seed layer. However Examiner neglects the rest of Applicants claimed steps including the **plasma treatment step following the first seed layer formation.**

Examiner has further provided no support for the notion that one of ordinary skill and in light of Applicants Specification and ordinary usage of terms would interpret Applicants term **"plasma treatment" of a seed layer following seed layer deposition** to be equivalent to **seed layer deposition by a plasma**

sputtering process (HDP-CVD), especially where Applicants have not disclosed material deposition during the plasma treatment step or disclosed use of plasma source gases that would result in seed layer deposition (or any other **material deposition layers**) during the **plasma treatment** step. Moreover, Applicants have **clearly separated the seed layer formation step from the "plasma treating" step in the claims and in the Specification:**

"then forming a first seed layer on the diffusion barrier;

then plasma treating the first seed layer in-situ with a first treatment plasma, said **first treatment plasma formed from plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;**

then forming a second seed layer on the first seed layer;"

In addition, Examiner has provided no support for the erroneous interpretation that one of ordinary skill in light of common usage of terms would interpret the **PVD copper seed layer deposition** of Chung et al. **to be a "plasma treatment" following formation of the PVD seed layer as Applicants have claimed.**

Moreover, the disclosure of Chung et al. in discussing a separate "plasma annealing" step of the TaN barrier layer (paragraph 0047) **with argon or argon/hydrogen plasma** demonstrates that one of ordinary skill would understand a plasma "treatment" or "annealing" step in ordinary usage to be distinguishable from a "seed layer" deposition process.

"Examiner is required to interpret the claims by giving the terms thereof the **broadest reasonable interpretation in their ordinary usage as they would be understood by one of ordinary skill in the art in light of the written specification,** including drawings, unless another meaning is intended by appellants as established in the written specification, and without reading into the claims any limitation or particular embodiment disclosed in the specification." *See e.g., In re Morris*, 127 F.3d. 1048, 1054-55, 44 USPQ2d 1023, 1027 (Fed. Cir 1997); *In re Zeltz* (893 F.2d 319, 321-22, 13 USPQ2d 1320, 1322 (Fed. Cir. 1989).

Thus, even assuming *arguendo*, a proper motivation to combine the teachings of the references, which Applicants do not concede, **such combination does not produce Applicants disclosed and claimed invention.**

The combination of Lin et al. and Chung et al. do not produce Applicants invention as claimed in **claim 1** including the including the combination of elements and order of process steps outlined **in bold type**:

"A method for forming a copper damascene comprising the steps of:

providing a substrate comprising a semiconductor substrate;

forming an insulator layer on the substrate;

forming a damascene opening through a thickness portion of the insulator layer;

forming a diffusion barrier layer to line the damascene opening;

then forming a first seed layer on the diffusion barrier;

then plasma treating the first seed layer in-situ with a

first treatment plasma, said first treatment plasma formed from plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;

then forming a second seed layer on the first seed layer;

forming a copper layer overlying the second seed layer according to an electro-chemical plating (ECP) process to fill the damascene opening; and,

planarizing the copper layer to form a metal interconnect structure."

"Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure." *In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).*

"Finally, when evaluating the scope of a claim, every limitation in the claim must be considered. Office personnel may not dissect a claimed invention into discrete elements and then

evaluate the elements in isolation. Instead, the claim as a whole must be considered." See, e.g., *Diamond v. Diehr*, 450 U.S. at 188-189, 209 USPQ at 9.

"A prior art reference must be considered in its entirety, i.e., as a whole including portions that would lead away from the claimed invention." *W.L. Gore & Associates, Inc., Garlock, Inc., 721 F.2d, 1540, 220 USPQ 303 (Fed Cir. 1983), cert denied, 469 U.S. 851 (1984).*

The combination of references further fails to disclose Applicants claimed method in **claim 18** including the combination of elements and order of process steps outlined **in bold type**:

"A method for forming a copper damascene comprising the steps of:

providing a substrate comprising a semiconductor substrate and metal interconnect structures;

forming a low-K dielectric insulator layer on the substrate;

forming a damascene opening through a thickness portion of

the low-K dielectric insulator layer;

forming a diffusion barrier layer to line the damascene opening;

then forming a first seed layer over the diffusion barrier layer;

then plasma treating the first seed layer with a first treatment plasma, said first treatment plasma formed from plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;

then forming a second seed layer on the first seed layer;

then plasma treating the second seed layer with a second treatment plasma, said second treatment plasma formed from plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;

forming a copper layer over the second seed layer according to an electro-chemical plating (ECP) process to fill the

damascene opening; and,

planarizing the copper layer to form a metal interconnect structure."

The combination of references further fails to disclose Applicants claimed method in **claim 46** including the combination of elements and order of process steps outlined **in bold type:**

"A method for forming a copper damascene seed layer with **improved seed layer step coverage to reduce void formation during ECP** comprising the steps of:

providing a damascene opening formed in a porous insulating substrate;

forming a diffusion barrier layer to line the damascene opening;

then forming a first seed layer on the diffusion barrier;

then plasma treating the first seed layer in-situ with a

first treatment plasma without depositing a material layer, said first treatment plasma formed from plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3;

then forming a second seed layer on the first seed layer;

then plasma treating the second seed layer in-situ with a second treatment plasma without depositing a material layer, said second treatment plasma formed from plasma source gases selected from the group consisting of argon, nitrogen, hydrogen, and NH_3; and,

depositing a copper layer on the second seed layer according to ECP to fill the damascene opening."

Conclusion

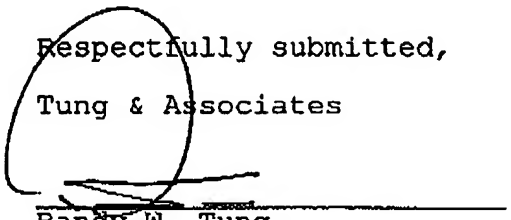
Since the combination of Lin et al. and Chung et al. fails to produce Applicants disclosed and claimed invention, it is insufficient to make out a *prima facie* case of obviousness with respect to Applicants independent claims, and therefore Applicants dependent claims.

Based on the foregoing, Applicants respectfully request reconsideration of the claims and submit that all of the Claims are now in condition for allowance. Such favorable action by the Examiner at an early date is respectfully solicited.

In the event that the present invention as claimed is not in a condition for allowance for any other reasons, the Examiner is respectfully invited to call the Applicants' representative at his Bloomfield Hills, Michigan office at (248) 540-4040 such that necessary action may be taken to place the application in a condition for allowance.

Respectfully submitted,

Tung & Associates



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